

SIXTH FRAMEWORK PROGRAMME



Project no.: 018480

EUROMBRA

Membrane bioreactor technology (MBR) with an EU perspective for advanced municipal wastewater treatment strategies for the 21st century.

STREP

Global Change and Ecosystems: Priority 1.1.6.3

Activity code: SUSTDEV-2004-3.II.3.2.2

D16 Cost analysis, literature data (incl. pilot plant trials conducted by partners) Supplement: aeration analysis (incl. pilot plant trials conducted by partners)

Due date of deliverable: -

Actual submission date: 01/05/07

Start of project: 1 October 2005

Duration: 3 years

Organization name of lead contractor for this deliverable:
Cranfield University

Revision: 1.0

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
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Supplement to D16 Cost analysis, literature data (incl. pilot plant trials conducted by partners), submitted 31/10/2006.

Rationale

Previous deliverables in this Work Package have attempted to ascertain the relationship between key hydraulic operational determinants, namely flux and permeability, and aeration parameters. The latter have comprised specific aeration demand (*SAD*) with respect to membrane area and permeate flow. In the current report the possible importance of in-module air velocity is considered with specific reference to data provided thus far by those partners conducting pilot plant trials.

Objectives

The aims of this Work Package are:

- to ascertain the overall costs associated with individual modes of operation of existing commercial membrane bioreactor technologies which have studied at pilot scale by several of the partners,
- to provide information on overall costs, as well as parameter values for appropriate base operating conditions, to be employed throughout the subsequent experimental programme, and
- to extend the analysis to encompass literature data and data arising from other WPs

Theoretical development

As outlined in previous reports, aeration demand allows for the assessment of energy simply by normalizing airflow against membrane area $\text{Nm}^3/(\text{m}^2\text{h})$:

$$SAD_m = \frac{Q_A}{A} \quad 1$$

Dividing this by the flux in m/h yields the aeration demand in Nm^3 per m^3 permeate product:

$$SAD_p = \frac{Q_A}{JA} \quad 2$$

For a given blower, aerator configuration and aerator depth the specific energy demand is directly proportional to SAD_p .

It has been postulated that the key aeration-related parameter impacting on flux may be air velocity. U , the mean in module air velocity, can be obtained from SAD_m and the module dimensions (Table 1) For a FS module:

$$U = \frac{2hSAD_m}{\delta} \quad 3$$

where δ is the channel thickness, x the panel thickness and h its height. For an HF module:

$$U = \frac{SAD_m h}{\left(\frac{1}{\phi} - \frac{d_f}{4}\right) \gamma} \quad 4$$

where d_f is the fibre diameter and ϕ the packing density in m^2 membrane area per m^3 module volume. So, for a value of U common to both modules:

$$\frac{SAD_{m,HF}}{SAD_{m,FS}} = \frac{2h_{FS}}{h_{HF}} \left(\frac{1}{\phi} - \frac{d_f}{4} \right) \quad 5$$

If the examples of a Zenon and a double deck Kubota module are taken ($h \sim 2\text{m}$ in both cases, see Table 1 below for other parameters) then, for continuous aeration:

$$\frac{SAD_{m,HF}}{SAD_{m,FS}} \sim 0.7$$

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The ratio is half this number for normal operation of the two systems (i.e. 50% aeration of the HF module). Equation 6 thus implies that an FS module is inherently less efficient than an HF one – even if the same aeration pattern is used for each.

Table 1: Module dimensions

	h, m	δ, m	d_f, m	φ, m^{-1}	$2h/\delta$	h/γ
Kubota	1	0.008			250	
Toray	1.5	0.006			1000*	
Zenon	2		0.0019	300		700
Puron	1.5		0.0013	330		554

*Double deck

Results

Data from pilot plant operation are provided in Table 2, and depicted in Figure 1. Only data where the aeration rate has been changed have been selected, and the mean gas velocity U incorporates the effect of intermittent aeration. Conditions under which the data are obtained are provided in other WPs. Interestingly, four of the five sets of data appear to indicate a threshold at around 150-180 m/h mean gas velocity. The exception is the double-deck Toray plant, which has a very long membrane channel flow length for a FS system and therefore a commensurately low SAD_p . For this plant, the rate of permeability decline was completely unchanged when U was raised from 140 to 210 m/h. Clearly, then, the threshold value is not ubiquitous.

Table 2: Aeration data

$U, m/h$	J, LMH	$SAD_p, m/h$	
Zenon pilot plant, 1			
122	25	32	
202	31	25	
302	30	16	
407	31	12	
Zenon pilot plant, 2*			
234	22		
180	22		
126	17		
Kubota pilot plant			
	a	b	
200	31	40	32
176	31	41	28
150	27	35	28
126	27	28	23
100	22		23
Toray pilot plant			
210	14		15
140	14		10

a Three monthly chemical cleans

b Monthly chemical cleans

*Germain, PhD thesis, Cranfield University, 2004.

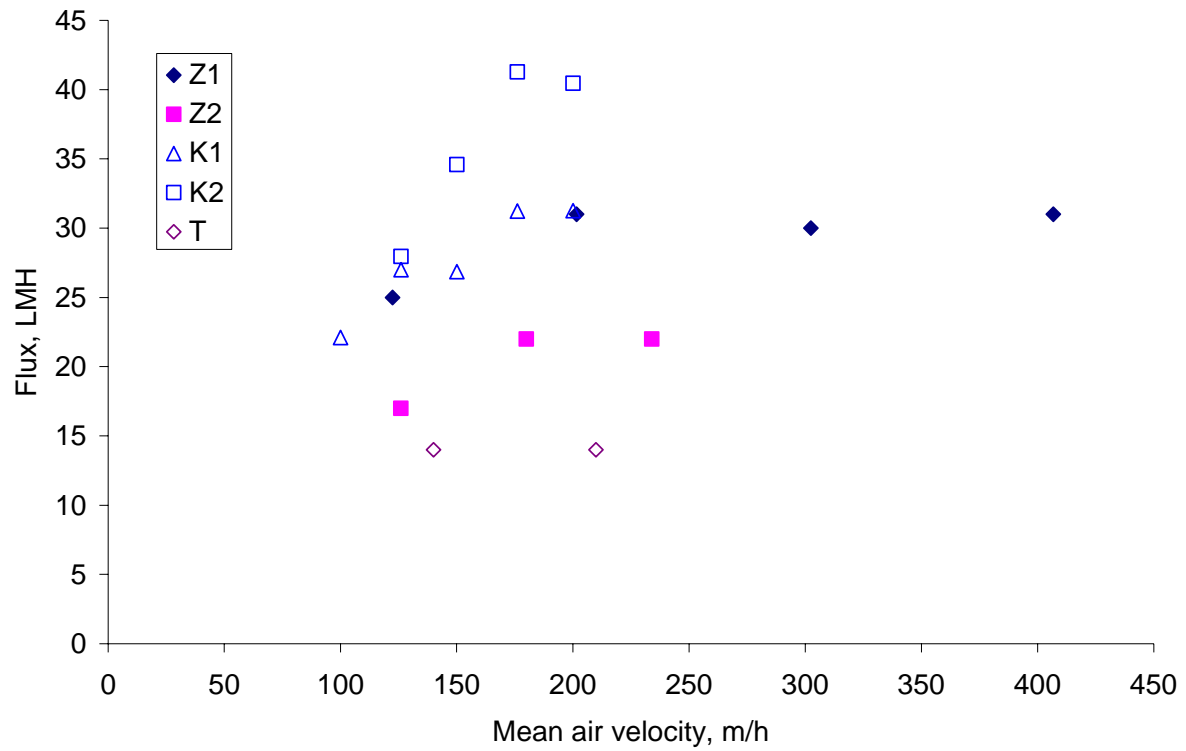


Figure 1 Sustainable or optimum flux vs. mean in-module air velocity

Conclusions

Based on the small range of evidence available, it is possible that a threshold value can be identified for membrane aeration and that this may be common to both FS and HF modules if based on mean in-module velocity U .